Biological Conservation 184 (2015) 18–26

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Conserving tigers in Malaysia: A science-driven approach for eliciting conservation policy change

D. Mark Rayan [a,b,*], Matthew Linkie [b,c]

[a] WWF Malaysia, 1 Jalan PJS 5/28A, Petaling Jaya Commercial Centre (PJCC), 46150 Petaling Jaya, Selangor, Malaysia
[b] Durrell Institute of Conservation and Ecology, University of Kent, Canterbury Kent CT2 7NZ, United Kingdom
[c] Fauna & Flora International, Singapore 247672, Singapore

ARTICLE INFO

Article history:
Received 30 June 2014
Received in revised form 23 December 2014
Accepted 29 December 2014

Keywords:
Carnivore
Conservation planning
Forest management
Logging
Panthera tigris
Wildlife corridor

ABSTRACT

The unprecedented economic growth occurring across Southeast Asia is causing large tracts of rainforest to be logged, converted to plantations or fragmented by infrastructure development. It also opens up forest to poachers which, in combination, places acute pressure on the region's large carnivores. Here, we focus on one of Malaysia's three priority tiger landscapes that illustrate these regional conservation challenges. The Royal Belum State Park (RBSP) and Temengor Forest Reserve (TFR) are connected by a strip of unprotected forest with portions assigned for conversion to monoculture plantations. To support government in setting aside wildlife corridors, we assessed: the abundance of tiger and principle prey under two different forest management regimes in RBSP and TFR; and, tiger habitat use in the unprotected forest strip, from which a spatially-explicit habitat model was produced to identify priority points of forest connectivity. Camera trapping revealed a threefold higher tiger density in the protected area (RBSP) than the forest reserve subjected to selective logging (TFR), which was likely explained by the higher relative abundance of its principal prey, seemingly lower levels of poaching as indicated from an independent study and presence of armed forces that may have deterred poachers. Two forest corridors were identified as being important for maintaining landscape connectivity and these findings were used to successfully lobby state government in affording them protection. This research offers an urgently needed approach for better managing Malaysian tiger habitat within forest reserves, which are predominantly designated for logging and have weak or non-existent wildlife protection measures.

1. Introduction

The unparalleled pace of economic growth in Asia is pushing numerous species to the edge of extinction. High demand for wildlife products, such as rhino horn and tiger bone, is increasing poaching pressures, while rapid infrastructure development, including a proliferation of road networks, is fragmenting forest habitat (Bennett, 2011; Laurance et al., 2009). In addition, fragmentation of habitat caused by selective logging particularly in terms of the edge effect (certain sensitive species avoid boundaries) poses a threat to the long-term survival of wildlife populations, particularly large mammals (Grieser Johns, 1997). These forces of change are most adversely affecting large-bodied mammals because of their prized status, relatively slow reproduction rates, wide range requirements and naturally low population densities (Clements et al., 2010).

Scientific research into the possible impact of infrastructure development and the identification of alternative options that are compatible with wildlife management are urgently needed. For these studies to be meaningful, they need to translate into on-the-ground action. This requires conservation scientists closely engaging with policy makers and conservation managers to greatly increase the likelihood of their recommendations being adopted (Knight et al., 2008; Laurance et al., 2009). Such an approach is pertinent for managing Peninsular Malaysia's forest. Here, 80% of its 59,230 km^2 forest estate is primarily designated for selective logging within Permanent Reserved Forests. Yet, of the presumed

Abbreviations: RBSP, Royal Belum State Park; TFR, Temengor Forest Reserve; BT-SLF, Belum-Temengor State Land Forest; PCRI, photo capture rate index; FR, Forest Reserve; RSF, resource selection functions; SECR, spatially explicit capture recapture.

* Corresponding author at: WWF Malaysia, 1 Jalan PJS 5/28A, Petaling Jaya Commercial Centre (PJCC), 46150 Petaling Jaya, Selangor, Malaysia. Tel.: +60 3 7450 3773.

E-mail addresses: markrayan78@gmail.com (D.M. Rayan), Matthew.Linkie@fauna-flora.org (M. Linkie).

http://dx.doi.org/10.1016/j.biocon.2014.12.024
0006-3207/

500 tigers (*Panthera tigris*) living in Malaysia, 85% of their habitat is located within these forests (Kawanishi et al., 2003). Best evidence now suggests that there are between 250 and 340 adult tigers in the country (DWNP and MYCAT, 2014).

Malaysia contains three large forest landscapes that are designated as both national and global tiger conservation priorities (Dinerstein et al., 2006; DWNP, 2008). All three areas span multiple land use types and maintaining their forest connectivity is critical for the long-term viability of tigers, as well as other wide-ranging mammals. However, beyond estimating tiger population density, no research on how spatial planning affects tigers has yet to be published from any of these landscapes (Kawanishi and Sunquist, 2004; Lynam et al., 2007; Rayan and Mohamad, 2009).

The challenges involved with managing these landscapes are exemplified by the Belum-Temengor Forest Complex in northern Peninsular Malaysia. It consists of a primary state park (Royal Belum State Park; RBSP) that is connected to a Permanent Reserved Forest (Temengor Forest Reserve; TFR) via state land forest that lacks a formal protection status (Belum-Temengor State Land Forest; BT-SLF) and contains a two lane public highway (Gerik-Jeli East–West Highway). In 2009, the susceptibility of BT-SLF to conversion became evident when several forest patches were clear-felled as part of a state government highland cash crop project. This happened despite existing national government plans that stressed the importance of maintaining forest integrity in the landscape (DTCP, 2005, 2009) and plans to build a viaduct, but during this time a lack of spatial planning expertise within government, readily available wildlife data and inter-agency and inter-sectoral coordination meant that wildlife concerns were not fully considered. Carnivores are known to cross roads in locations that vary with passage characteristics, road-related attributes, surrounding habitat characteristics, and human disturbance levels and therefore, understanding the habitat use patterns of a species on both sides of a highway is critical to identify a matrix of suitable patches surrounding proposed viaduct locations, so that these are protected (Clevenger and Waltho, 2000).

Where tigers occur and how they move within the Belum-Temengor Forest Complex, and indeed other such mosaic landscapes, is poorly understood in Malaysia and therefore a conservation research priority. Recognising this, we carried out wildlife surveys with an explicit aim of providing science-based management recommendations to the Perak State authorities to identify corridor and viaduct placements that closely matched high quality large mammal habitat (Rayan et al., 2012). In this paper, we conduct the first comprehensive tiger and prey assessment in a global priority Tiger Conservation Landscape in Malaysia. We aim to investigate species abundance in two forest estates under different management regimes, tiger habitat use within the BT-SLF forest strip and then use these results to work with government to set aside critically important corridors and identify potential viaduct locations. Finally, we describe our approach in engaging different government agencies and its outcome in influencing policy.

2. Material and methods

2.1. Study areas

The Belum-Temengor Complex consists of three study areas; RBSP, BT-SLF and TFR, which are all located in the state of Perak (101°15′0″–101°46′0″E and 5°55′0″N–5°0′0″N; Fig. 1) and cover 2922 km^2. RBSP is home to an estimated 740 indigenous people (*Orang Asli*) and TFR an estimated 5000 indigenous people (Department of *Orang Asli* Affairs, unpublished data). Within the BT-SLF, there are about 570 indigenous people (DTCP, 2009). The *Orang Asli* primarily hunt small mammals and primates, and rear poultry, but do not keep larger livestock that might be attractive to tigers (Mark Rayan, unpublished data). Over the past decade, there have been only two incidents of people being attacked by tigers in the Complex (Mark Rayan, unpublished data).

The 1175 km^2 RBSP was officially gazetted in 2007 as a strictly protected area with only non-exploitive commercial activities, such as tourism by the edge of a lake. It ranges from 260 m to 1533 m a.s.l and consists of lowland dipterocarp (5.6%), hill dipterocarp (71.5%), upper dipterocarp (20.9%) and montane (2.0%) forests. The 1489 km^2 TFR was officially gazetted in 1991 as a Permanent Reserved Forest and is an active production forest undergoing selective logging through a second cycle. The forest ranges from 260 m to 2160 m a.s.l and consists of lowland dipterocarp (4.2%), hill dipterocarp (34.4%), upper dipterocarp (41.7%) and montane (19.7%) forests.

RBSP and TFR are intersected by the 131 km^2 BT-SLF forest strip (2.4 × 33.9 km) that is bisected by the Gerik-Jeli East–West Highway, which provides access to poachers and is a potential barrier to tiger movement (Clements et al., 2010; WWF-Malaysia, 2011). At the time of the study, BT-SLF was classified as 'state land forest' and therefore had no protection status, making it vulnerable to conversion for agriculture, plantations or infrastructure by state authorities. The BT-SLF ranges from 260 to 1265 m a.s.l. and consists of lowland dipterocarp (0.2%), hill dipterocarp (43.5%), upper hill dipterocarp (55.9%) and montane (0.4%) forests.

2.2. Data collection and field methods

Two field survey designs were applied from October 2009–January 2011. For the larger areas of RBSP and TFR, 2 × 2 km grid cell sampling units were used to guide the placement of camera traps for investigating tiger density and relative prey abundance (Karanth et al., 2008). To assess finer-scale tiger habitat use in the BT-SLF corridor, 1 × 1 km grid cell sampling units were surveyed for indirect sign. Camera trapping was not able to be conducted during sign surveys in BT-SLF as there were not enough camera traps due to problems with theft and damage by wildlife.

Camera trapping was first conducted for about nine months in TFR and then RBSP, with a sampling area of about 400 km^2 for each of the tiger density surveys. In 2 × 2 km grid cells, 35 fixed location paired camera traps were set to record both flanks of a passing tiger. To maximise study area coverage, as part of a separate study on habitat use, another 70 single placement camera traps were set in neighbouring grid cells. To increase spatial coverage within grid cells, these 70 traps were moved once within the same cell after 3–4 months of operation, corresponding to a total of 140 single placements. These provided a total of 175 camera placements with about an average inter-trap distance of 1 km for tiger density surveys. To increase species detection rates, placements were made along forest trials, ridge trails and inactive logging roads. Camera traps were checked every 2–3 months to retrieve data and replace batteries.

In the BT-SLF study area, indirect species signs were recorded through three repeat surveys (each defined as a sampling occasion) in a grid cell over five months. Surveys were conducted by six teams, each of two personnel (a field biologist and an indigenous guide). Each team was rotated in sequence to minimise observer bias between temporal replicates. Repeat surveys in a grid cell were conducted at 1–2 month intervals. Each team was required to survey a minimum of 1 km per 1 km^2 grid cell containing tiger habitat. Each team intensively searched areas considered to have the highest likelihood of tiger and prey sign (i.e. tracks <1 month old), such as forest trails, ridges, sand beds, river banks, saltlicks and logging roads.

Presence of tiger, prey species: sambar (*Rusa unicolor*), muntjac (*Muntiacus muntjak*), wild pig (*Sus scrofa*) and gaur (*Bos gaurus*),